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Please direct correspondence to:

Dr. Eric R. Loft, Editor in Chief
California Fish and Game
1416 Ninth Street
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CONTENTS

A Review of the California Caddisflies (Trichoptera) Listed as Candidate Species on the 1989 Federal "Endangered and Threatened Wildlife and Plants; Animal Notice and Review	45
..... Nancy A. Erman and Christopher D. Nagano	
Age, Length, Weight, Reproductive Cycle and Fecundity of the Monkeyface Prickleback (<i>Cebidichthys violaceus</i>)	57
..... William H. Marshall and Tina Wyllie Echeverria	
Changes in Distribution of Cackling Canada Geese in Autumn	65
..... Dennis G. Raveling and David S. Zezulak	
The Use of High-cut Stumps by Birds	78
..... Michael L. Morrison	
BOOK REVIEWS	
Natural History of the White-Inyo Range, Eastern California . Edited by Clarence A. Hall, Jr. 1991	84
..... Vernon C. Bleich	
Midnight Wilderness: Journeys in Alaska's Arctic National Wildlife Refuge. Debbie S. Miller. 1990	85
..... Vernon C. Bleich	
IN MEMORIAM	87

A REVIEW OF THE CALIFORNIA CADDISFLIES (TRICHOPTERA) LISTED AS CANDIDATE SPECIES ON THE 1989 FEDERAL "ENDANGERED AND THREATENED WILDLIFE AND PLANTS; ANIMAL NOTICE OF REVIEW"

NANCY A. ERMAN

Department of Forestry and Resource Management
University of California
Berkeley, CA 94720

and

CHRISTOPHER D. NAGANO

U.S. Fish and Wildlife Service
Sacramento Endangered Species Office
2800 Cottage Way, Room E-1823
Sacramento, CA 95825

Seventeen species of Trichoptera are listed for California in the Federal Register as candidate species on the 1989 federal endangered and threatened list. The literature on these species is widely scattered and difficult for land managers, consultants, and researchers to obtain. In this paper we give information for each species on the federal list. We have included category, family, geographical range, habitat, additional notes, and references. Trichoptera of California's freshwater habitats have never been systematically surveyed. The 1989 list should be considered a preliminary attempt to identify caddisfly species in possible need of protection.

INTRODUCTION

The 1989 Federal list of candidate species of endangered and threatened Trichoptera (Federal Register 1989) was determined, in California, by querying interested parties in the state (researchers, agency biologists, and the general public) about species they considered rare or threatened. The list should be viewed as preliminary and incomplete. It represents an attempt to begin recognizing the serious threats to the state's freshwater invertebrates and to the habitats they require for existence.

No systematic survey has been made of California caddisflies, a major shortcoming of the present list. It is unfortunate that a state as biologically diverse and as prosperous as California has never undertaken the task of surveying the invertebrates of its freshwater habitats. Many of these habitats are now lost or threatened. With them we likely have already lost unknown numbers of endemic species. For example, only 5% to 20% of the historical wetland acreage remains in the state, and what remains is subject to many threats (Jensen et al. 1990). In most of the San Francisco

Estuary more than 90% of the total weight of benthic invertebrates is now introduced species (Cohen 1990). Such change can occur only at great cost to native species. In the Modoc National Forest, 78% of the riparian areas are in poor or fair condition (U.S. General Accounting Office 1988); in the Plumas National Forest, half (47.6%) of small stream acreage is rated in poor condition and only 20% of all running water fish habitat is in good condition (US Forest Service 1988). "Aquatic habitats are the most dramatically and completely altered biotic communities in California" (Jensen et al. 1990).

Our study reviews the status of the 17 species of California Trichoptera currently listed as candidates on the Federal Endangered and Threatened List. We have surveyed the published literature on these species. Ranges and habitat requirements provided here should not be considered complete, but rather, as preliminary information that will be expanded as more data become available. Taxonomic revisions also may cause changes to this list. Twenty-six species are listed for Oregon; 67 species are listed for the entire United States. This paper pertains to the California species only.

The identity of most of these species can be confirmed from adult males only; therefore, confirmation of a suspected candidate species must be made by an expert. However, larval collections often give an indication of whether or not rare species may be present. For more information and larval illustrations, we recommend consulting *Larvae of the North American Caddisfly Genera* (Wiggins 1977). Where changes in classification have occurred since publication of that standard reference, we have so noted in the following descriptions. The book, *Aquatic Insects of California* (Usinger 1956), should be used with caution because much of it is out of date.

References given with each species contain information particular to that species. Species are listed alphabetically by family first and then alphabetically by genus and species. This order is not identical to that used in the Federal Register. Common names are written as they appear in the Federal Register. A category rating of 1 on the Federal list indicates taxa for which substantial biological information is available to support listing as endangered or threatened. A category 2 rating indicates species for which listing may be appropriate but information is not available to conclusively support vulnerability and threat. A category 3 rating indicates species that were once being considered for listing but are not being considered at present because they are one of the following: 1) now thought to be extinct (subcategory 3A), 2) do not meet the legal definition of species based on published revisions and monographs (subcategory 3B), or 3) now are considered more abundant and widespread than previously thought (subcategory 3C), (Federal Register 1989). Two of the California Trichoptera species on the Federal candidate list are in category 1, fourteen are in category 2, and one is in category 3B. The last is technically not a federal candidate species at this time; however, we have included it herein because its category seems incorrect based on published literature.

Caddisflies are a highly diverse group of aquatic insects, found in nearly every freshwater possibility, often confined to rather narrow habitat requirements, and,

therefore, vulnerable to changes in their environments. We note that most of the species and several genera (e.g. *Cryptochia*, *Farula*, *Neothremma*) listed for California and Oregon are restricted to upper watershed streams and are found in clear, cold, rapidly moving water or in small spring streams. These habitats are under ever-increasing impacts from such activities as logging, grazing, and water diversion.

CANDIDATE SPECIES

1) *Diplectrona californica* Banks 1914; California diplectronan caddisfly.

CATEGORY: Candidate 2

FAMILY: Hydropsychidae

RANGE: California, San Bernardino County, Claremont (type locality); Thurman Flats.

HABITAT: Unknown for this species, but rapid portions of small, cool streams for other species of the genus.

NOTES: Original illustration by Banks is unclear. Good illustration of male by Flint (1966), who considered *D. margarita* Denning 1965 synonymous with *D. californica*. Adults collected in May. Female described by Denning (1965). No information on larva.

REFERENCES:

Banks, N. 1914. American Trichoptera—notes and descriptions. Canadian Entomologist 46 (5):252-258.

Denning, D.G. 1965a. New Hydropsychidae (Trichoptera). Journal of Kansas Entomological Society 38(1):75-84.

Flint, O.S. 1966. Notes on certain Nearctic Trichoptera in the Museum of Comparative Zoology. Proceedings of the United States National Museum 118(3530):373-389.

2) *Parapsyche extensa* Denning 1949; King's Creek parapsyche caddisfly.

CATEGORY: Candidate 2

FAMILY: Hydropsychidae

RANGE: California, Shasta County, Lassen Volcanic National Park, Kings Creek Meadows, elevation 2,286 m (7,500'), (type locality).

HABITAT: Unknown for this species, but small cold streams for other species of the genus.

NOTES: Known only from a single male collected in July. Has been confused in the past with *Parapsyche turbinata* Schmid (Givens and Smith 1980).

REFERENCES:

Denning, D. G. 1949. New species of Nearctic caddis flies. Bulletin of the Brooklyn Entomological Society 44(2):37-48.

_____. 1956a. Trichoptera. Pages 237-270. In Usinger, R.L.(ed). Aquatic Insects of California. University of California Press, Berkeley. 508 p.

Givens, D.R. and S.D. Smith. 1980. A Synopsis of the Western Arctopsychinae (Trichoptera: Hydropsychidae). Melanderia 35. 24p.

3) *Lepidostoma ermanae* Weaver 1988; Cold Spring caddisfly; (listed as *Lepidostoma* sp. in the 1989 Federal Register list).

CATEGORY: Candidate 1

FAMILY: Lepidostomatidae

RANGE: California, Nevada County, Sagehen Creek basin, spring source of a first order tributary of Sagehen Creek, (type locality).

3) *Lepidostoma ermanae* Weaver 1988; cont.

HABITAT: One very cold (3-4°C) spring source on a north-facing slope in a permanently shaded area, elevation 2,042 m (6700').

NOTES: Known only from the type locality. An extensive survey of other springs in the area revealed no other populations of this species. A rise in temperature of as little as 2°C could eliminate this species. Adults emerge from mid-July to mid-August.

REFERENCES:

- Erman, N. A. 1989. Species composition, emergence, and habitat preferences of Trichoptera of the Sagehen Creek basin, California, U.S.A. *Great Basin Naturalist* 49(2):186-197.
- Erman, N. A. and D. C. Erman. 1990. Biogeography of caddisfly (Trichoptera) assemblages in cold springs of the Sierra Nevada (California, USA). *California Water Resources Center, University of California, Contribution* 200. 29 p.
- Weaver, J.S., III. 1988. A synopsis of the North American Lepidostomatidae (Trichoptera). *Contributions of the American Entomological Institute* 24(2). 141 p.

4) *Cryptochia denningi* Wiggins 1975; Denning's cryptic caddisfly.

CATEGORY: Candidate 2

FAMILY: Limnephilidae

RANGE: California, Tulare County, Sequoia National Park, Dorst Creek Campground, (type locality).

HABITAT: Unknown for this species but small first- and second-order mountain streams for other species of the genus. Larvae of the genus often found above the water surface on damp wood or in wet leaves at the water's edge.

NOTES: Described from one male collected in June. Female and larva unknown. In other species of the genus, the unusual larval case is constructed of small woody pieces, possibly rounded on the outer edges by the mandibles of the larva. See illustration in Wiggins (1977). Wisseman and Anderson (1987) found that larvae of a related species, *Cryptochia pilosa* (Banks), were semi-terrestrial, living in organic debris above the water surface, often found in damp leaves and wood on stream margins or in floating material behind debris jams.

REFERENCES:

- Wiggins, G.B. 1975. Contributions to the systematics of the caddisfly family Limnephilidae (Trichoptera). II. *Canadian Entomologist* 107(3):325-336.
- Wisseman, R.W. and N.H. Anderson. 1987. The life history of *Cryptochia pilosa* (Trichoptera: Limnephilidae) in an Oregon Coast Range watershed. Pages 243-246. *In* Bourmaud, M. and H. Tachet (eds.), *Proceedings of the 5th international symposium on Trichoptera*, Lyon, France, 21-26 July 1986, Dr W. Junk Publishers, Dordrecht. 397 p.

5) *Cryptochia excella* Denning 1964; Kings Canyon cryptochian caddisfly.

CATEGORY: Candidate 2

FAMILY: Limnephilidae

RANGE: California, Fresno County, Kings Canyon National Park, elevation 1951 m (6,400') (type locality); Nevada County, Sagehen Creek basin, Lower Kiln Tributary, upper reaches. Also present in other cold springs in the same basin.

HABITAT: Small, cold spring (first-order) streams (temperature 3-6°C).

NOTES: Adults emerge in June and July. In other species of the genus, the unusual larval case is constructed of small woody pieces, possibly rounded on the outer edges by the mandibles of the larva. See illustration in Wiggins (1977). See notes under *Cryptochia denningi*, above, for information on larval habitat of a related species.

REFERENCES:

- Denning, D.G. 1964. Descriptions of five new Trichoptera. *Pan-Pacific Entomologist* 40(4):241-245.
- Erman, N.A. 1989. Species composition, emergence, and habitat preferences of Trichoptera of the Sagehen Creek basin, California, U.S.A. *Great Basin Naturalist* 49(2):186-197.
- Erman, N.A. and D.C. Erman. 1990. Biogeography of caddisfly (Trichoptera) assemblages in cold springs of the Sierra Nevada (California, USA). *California Water Resources Center, University of California, Contribution* 200. 29p.

6) *Cryptochia shasta* Denning 1975; Confusion caddisfly.

CATEGORY: Candidate 2

FAMILY: Limnephilidae

RANGE: California, Shasta County, creek near Castle Crags State Park (type locality). (See NOTES below)

HABITAT: Unknown for this species. Small, cold first- and second-order mountain streams for other species of this genus.

NOTES: Adults emerge in May, June, and July. May be synonymous with *Cryptochia califca* found in Sierra and Nevada Counties and also rare (Erman 1989). See notes under *Cryptochia denningi*, above, for information on larval habitat of a related species.

REFERENCES:

- Denning, D.G. 1975. New species of Trichoptera from western North America. *Pan-Pacific Entomologist* 51(4):318-326.
- Erman, N. A. 1989. Species composition, emergence, and habitat preferences of Trichoptera of the Sagehen Creek basin, California, U.S.A. *Great Basin Naturalist* 49(2):186-197.

7) *Desmona bethula* Denning 1954; Amphibious caddisfly.

CATEGORY: Candidate 2

FAMILY: Limnephilidae

RANGE: California, Sierra County, Snag Lake, 7 miles (11 km) north of Sierra City (type locality); Nevada County, Plumas County, Madera County, Mariposa County, Mono County, and Sequoia National Park.

HABITAT: Small first-order streams in open, wet-meadow areas. Occasionally found in beaver ponds on second-order streams.

NOTES: Larvae leave the water at night to feed on riparian vegetation during the final instar. They return to water at sunrise. Grazing livestock have impact on their feeding habitat at stream edges. Major adult emergence is in late September and early October.

REFERENCES:

- Denning, D.G. 1954. New species of western Trichoptera. *Journal of Kansas Entomological Society* 27(2):57-64.
- . 1956a. Trichoptera. Pages 237-270. In Usinger, R.L. (ed). *Aquatic Insects of California*. University of California Press, Berkeley. 508 p.
- Erman, N.A. 1981. Terrestrial feeding migration and life history of the stream-dwelling caddisfly, *Desmona bethula* (Trichoptera: Limnephilidae). *Canadian Journal of Zoology* 59(9):1658-1665.
- Erman, N. A. and D. C. Erman. 1990. Biogeography of caddisfly (Trichoptera) assemblages in cold springs of the Sierra Nevada (California, USA). *California Water Resources Center, University of California, Contribution* 200. 29p.
- Wiggins, G.B. and R.W. Wisseman. 1990. Revision of the North American caddisfly genus *Desmona* (Trichoptera: Limnephilidae). *Annals of the Entomological Society of America* 83(2):155-161.

8) *Ecclisomyia bilera* Denning 1951; King's Creek ecclisomyian caddisfly.

CATEGORY: Candidate 2

FAMILY: Limnephilidae

RANGE: California, Shasta County, Lassen Volcanic National Park, Kings Creek Meadows, elevation 2,256 m (7,400') (type locality); Sierra County, springs in Lincoln Creek basin.

HABITAT: Small, cold springs in open meadows.

NOTES: Adults emerged in May at an elevation of 2,195 m (Lincoln Creek springs) and emerged later (July and August) at higher elevations and farther north. Grazing cattle have impact on habitat.

REFERENCES:

- Denning, D.G. 1951. Records and descriptions of Nearctic caddisflies. Part III. Journal of Kansas Entomological Society 24(4):157-162.
- _____. 1956a. Trichoptera. Pages 237-270. In Usinger, R.L. (ed). Aquatic Insects of California. University of California Press, Berkeley. 508 p.
- Erman, N.A. and D.C. Erman. 1990. Biogeography of caddisfly (Trichoptera) assemblages in cold springs of the Sierra Nevada (California, USA). California Water Resources Center, University of California, Contribution 200. 29p.

9) *Goeracea oregona* Denning 1968; Sagehen Creek goeracean caddisfly.

CATEGORY: Candidate 1

FAMILY: Limnephilidae (sometimes placed in Goeridae, see, for example, Schmid 1980)

RANGE: Oregon, Jackson County, French Gulch Road (type locality); California, Nevada County, Sierra County.

HABITAT: Springs at temperatures of around 9-11°C.

NOTES: Only two species in this genus. Other species, *G. genota* (Ross), has not been reported in California. Identification of the unusual larva is strong evidence in California that *G. oregona* is present. Common name is unfortunate and confusing; species is not present in Sagehen Creek and scientific name (*oregona*) indicates state of type locality. Has an extended emergence period; adults collected at one site in June, July, August, September, and October. Type specimens collected in May.

REFERENCES:

- Denning, D.G. 1968. New and interesting North American Trichoptera. Pan-Pacific Entomologist 44(1):17-26.
- Erman, N.A. 1989. Species composition, emergence, and habitat preferences of Trichoptera of the Sagehen Creek basin, California, U.S.A. Great Basin Naturalist 49(2):186-197.
- Erman, N.A. and D.C. Erman. 1990. Biogeography of caddisfly (Trichoptera) assemblages in cold springs of the Sierra Nevada (California, USA). California Water Resources Center, University of California, Contribution 200. 29 p.
- Schmid, F. 1980. Genera des Trichoptères du Canada et des états adjacents. Les insectes et arachnides du Canada, Part 7. Agriculture Canada Publication, 1692. 296 p.
- Wiggins, G.B. 1973. New systematic data for the North American caddisfly genera *Lepania*, *Goeracea*, and *Goerita* (Trichoptera: Limnephilidae). Life Sciences Contributions of the Royal Ontario Museum No. 91. 33p.

10) *Limnephilus atercus* Denning 1965; Fort Dick limnephilus caddisfly.

CATEGORY: Candidate 2

FAMILY: Limnephilidae

RANGE: California, Del Norte County, Fort Dick (type locality); Oregon, Lane County,

Waldo Lake.

HABITAT: Unknown.

NOTES: Larva unknown. Described only from adult male. Only date given in description is year of collection, 1963. But Oregon collection on July 23, 1969.

REFERENCES:

Anderson, N.H. 1976. The distribution and biology of the Oregon Trichoptera. Agricultural Experiment Station, Oregon State University, Corvallis, Oregon, Technical Bulletin 134. 152 p.

Denning, D.G. 1965*b*. New rhyacophilids and limnephilids (Trichoptera: Rhyacophilidae and Limnephilidae). Canadian Entomologist 97(7):690-700.

11) *Rhyacophila amabilis* Denning 1965; Castle Lake rhyacophilan caddisfly.

CATEGORY: Candidate 3B

FAMILY: Rhyacophilidae

RANGE: California, Siskiyou County, Castle Lake (type locality).

HABITAT: Unknown.

NOTES: Known only from the type specimen. Adult male collected in May. Female and larva unknown. Larvae of this family do not build cases. Species was reevaluated by Schmid (1970) and by Peck and Smith (1978). They considered the species valid. Therefore, the candidate 3B category seems unfounded, and reasons for it are unknown to us.

REFERENCES:

Denning, D.G. 1965*b*. New rhyacophilids and limnephilids (Trichoptera: Rhyacophilidae and Limnephilidae). Canadian Entomologist 97(7):690-700.

Peck, D.L. and S.D. Smith. 1978. A revision of the *Rhyacophila coloradensis* complex (Trichoptera: Rhyacophilidae). Melanderia 27. 24 p.

Schmid, F. 1970. Le genre *Rhyacophila* et la famille des Rhyacophilidae (Trichoptera). Entomological Society of Canada Memoirs 66. 230 p.

12) *Rhyacophila lineata* Denning 1956; Castle Crags rhyacophilan caddisfly.

CATEGORY: Candidate 2

FAMILY: Rhyacophilidae

RANGE: California, Shasta County, Castle Crags State Park (type locality).

HABITAT: Unknown.

NOTES: Published information on the type specimen only. Female and larva not described in literature. Male collected in June. Species reevaluated by Schmid (1970).

REFERENCES:

Denning, D.G. 1956*b*. Several new species of western Trichoptera. Pan-Pacific Entomologist 32(2):73-80.

Schmid, F. 1970. Le genre *Rhyacophila* et la famille des Rhyacophilidae (Trichoptera). Entomological Society of Canada Memoirs 66. 230 p.

13) *Rhyacophila mosana* Denning 1965; Bilobed rhyacophilan caddisfly.

CATEGORY: Candidate 2

FAMILY: Rhyacophilidae

RANGE: California, Shasta County, Castle Crags State Park, (type locality).

HABITAT: Unknown.

NOTES: Male and female described. Larva unknown. Adults collected in late October. Schmid (1970) designated this species as doubtful or insufficiently known.

13) *Rhyacophila mosana* Denning 1965; cont.

REFERENCES:

- Denning, D.G. 1965c. New Trichoptera from United States and Mexico. *Pan-Pacific Entomologist* 41(4):263-272.
- Schmid, F. 1970. Le genre *Rhyacophila* et la famille des Rhyacophilidae (Trichoptera). *Entomological Society of Canada Memoirs* 66. 230 p.

14) *Rhyacophila spinata* Denning 1965; Spiny rhyacophilan caddisfly.

CATEGORY: Candidate 2

FAMILY: Rhyacophilidae

RANGE: California, Sierra County, New York Ravine, tributary of North Yuba River near Highway 49, (type locality); recollected in 1984 (by N.A. Erman) near type locality at elevation 1,067 m (3,500'); Placer County, Lady's Canyon, elevation 701 m (2,300')(Fields 1981); Plumas County, Granite Gulch near Tobin (Wold 1974).

HABITAT: Adults collected on vegetation beside second-order streams, rapid water. Larva unknown. Rather broad elevational range.

NOTES: Error in locality in original description has been corrected here (New York Ravine near Highway 49 is a tributary of the North Fork of the Yuba River, not the Downie River and the county is Sierra, not Yuba). Female described by Fields (1981). Adults emerge in spring of year, records from March, April, and June.

REFERENCES:

- Denning, D.G. 1965b. New rhyacophilids and limnephilids (Trichoptera: Rhyacophilidae and Limnephilidae). *Canadian Entomologist* 97(7):690-700.
- Fields, W.C., Jr. 1981. New species of *Rhyacophila* from California (Trichoptera: Rhyacophilidae). *Pan-Pacific Entomologist* 57(4):500-503.
- Wold, J. 1974. Systematics of the genus *Rhyacophila* (Trichoptera: Rhyacophilidae) in western North America with special reference to the immature stages. M.S. Thesis, Oregon State University, Corvallis, 229 p.

15) *Farula praelonga* Wiggins and Erman 1987; Long-tailed caddisfly; (listed as *Farula* sp. in the 1989 Federal Register list).

CATEGORY: Candidate 2

FAMILY: Uenoidae (*Farula* formerly included in Limnephilidae)

RANGE: California, Sierra County, tributary of New York Ravine, tributary of North Yuba River, elevation 1,067 m (3,500'), (type locality); Big Springs on Highway 49 above Sierra City, elevation 1,615 m (5,300').

HABITAT: First- and second-order streams with rapid flow. Larvae attached to rocks.

NOTES: Larvae of genus construct very slender, dark-colored, "horn"-shaped case. Formerly placed in Limnephilidae, now in Uenoidae (Wiggins et al. 1985). Adults emerge in early spring [March, at 1,067 m (3,500') elevation] while snow still on ground.

REFERENCES:

- Wiggins, G.B., J.S. Weaver III, and J.D. Unzicker. 1985. Revision of the caddisfly family Uenoidae (Trichoptera). *Canadian Entomologist* 117(6):763-800.
- Wiggins, G.B. and N.A. Erman. 1987. Additions to the systematics and biology of the caddisfly family Uenoidae (Trichoptera). *Canadian Entomologist* 119(10):867-872.

16) *Neothremma genella* Denning 1966; Golden-horned caddisfly.

CATEGORY: Candidate 2

FAMILY: Uenoidae (*Neothremma* formerly included in Limnephilidae)

RANGE: California, Plumas County, Nelson Creek, southwest of Johnsville (type locality); Madera County, North Fork of Arline Creek, elevation 2,377 m (7,800'); Sierra County, tributary of New York Ravine, tributary of North Yuba River, elevation 1,067 m (3,500').

HABITAT: Primarily second-order streams but also found in smaller first-order streams. Apparently has broad elevational range. Larvae present on rocks in rapid water.

NOTES: Formerly placed in Limnephilidae, now in Uenoidae (Wiggins et al. 1985). Larval case very slender, golden-colored, "horn"-shaped. Other ecological information, female and larval descriptions in Wiggins and Erman (1987). Adults emerge in late September and early October at 1,067 m (3,500') elevation.

REFERENCES:

Denning, D.G. 1966. New and interesting Trichoptera. Pan-Pacific Entomologist 42(3):228-238.

_____. 1975. New species of Trichoptera from western North America. Pan-Pacific Entomologist. 51(4):318-326.

Wiggins, G.B., J.S. Weaver III, and J.D. Unzicker. 1985. Revision of the caddisfly family Uenoidae (Trichoptera). Canadian Entomologist 117(6):763-800.

Wiggins, G.B. and N.A. Erman. 1987. Additions to the systematics and biology of the caddisfly family Uenoidae (Trichoptera). Canadian Entomologist 119(10):867-872.

17) *Neothremma siskiyou* Denning 1975; Siskiyou caddisfly.

CATEGORY: Candidate 2

FAMILY: Uenoidae (*Neothremma* formerly included in Limnephilidae)

RANGE: California, Siskiyou County, Salmon Mountains, elevation 1,753 m (5,750'), (type locality).

HABITAT: Unknown.

NOTES: Formerly placed in Limnephilidae, now in Uenoidae (Wiggins et al. 1985). Identified only from adult males. Female and larva unknown. Adult male collected in August. No ecological information.

REFERENCES:

Denning, D.G. 1975. New species of Trichoptera from western North America. Pan-Pacific Entomologist. 51(4):318-326.

Wiggins, G.B., J.S. Weaver III, and J.D. Unzicker. 1985. Revision of the caddisfly family Uenoidae (Trichoptera). Canadian Entomologist 117(6):763-800.

CONCLUSIONS AND RECOMMENDATIONS

The lack of methodical biological surveys of California's aquatic habitats is a major impediment to meaningful evaluation of threatened aquatic invertebrates. Until such surveys are conducted, useful recommendations concerning the status of each species on the foregoing list can not be made. In addition, surveys of areas contiguous to California are also needed to determine species distribution. Trichoptera of Oregon have been rather well-studied while Trichoptera of Nevada and Mexico are relatively little-known. The difference between collections and surveys becomes

important when we are attempting to determine the range and abundance of a species. A great deal of our knowledge of Trichoptera in California is based on collections, not surveys. Collections are likely to be disproportionately biased by the collector and where and when the collector spends his or her field time. Further, this list is probably far from complete if we consider the major alterations that have occurred in California's freshwaters. Nevertheless, it is a beginning. A survey of the known specific habitat types of the Trichoptera discussed above would be the logical next step. A sampling program could be devised for each species by beginning with known localities as the locus. Sampling could be done in similar habitats at similar elevations and at increasing distances from that point. Surveys could then be expanded or curtailed based on these findings.

Accompanying the field surveys should be a survey of existing collections, both public and private, to determine the extent of unpublished information on the above 17 species. We know of a few unpublished records, but have not included them here, because no comprehensive survey has been done. Such a survey could be initiated by a questionnaire sent to all researchers of Trichoptera who may have knowledge of California species. A protocol for verification of records of candidate endangered or threatened species should be established by the Fish and Wildlife Service working closely with universities and museums.

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AGE, LENGTH, WEIGHT, REPRODUCTIVE CYCLE AND FECUNDITY OF THE MONKEYFACE PRICKLEBACK (*CEBIDICHTHYS VIOLACEUS*)

WILLIAM H. MARSHALL
Evergreen Estates #214
1215 Evergreen Ct.
Clarkston, WA 99403-2800

and

TINA WYLLIE ECHEVERRIA¹
National Marine Fisheries Service
Southwest Fisheries Center, Tiburon Laboratory
3150 Paradise Drive
Tiburon, CA 94920

Life history characteristics of age, length, weight, reproductive season and fecundity of the monkeyface prickleback (*Cebidichthys violaceus*) were investigated. Most specimens were obtained from poke pole anglers during low tides at Dillon Beach, California. Males and females were aged to 18 years old, with males attaining a larger size. Sexual dimorphic growth occurred after age eight, coincident with maturity in females. A complete length-weight curve was constructed. The age-weight curves for males and females were similar. Females mature as early as four years of age with 100% mature by age eight. Spawning occurs from February through April. Two adult females had an estimated 17,000 and 40,000 mature eggs each.

INTRODUCTION

The monkeyface prickleback (*Cebidichthys violaceus*) known to anglers as the monkeyface "eel", are found in rocky intertidal and subtidal habitats ranging from San Quintin Bay, Baja California (Miller and Lea 1972) to Brookings, Oregon (Barton 1978). They are prime targets of the few sports anglers who "poke pole" in the rocky intertidal zone at low tide (Squire and Smith 1977). Little is known about the life history of this species. This paper presents the life history parameters of length, weight, and age of both sexes, as well as some aspects of ovarian maturity, reproductive season and fecundity of females.

METHODS

A total of 401 fish were examined. Of these, 369 were collected 0.5 to 2 km north of Dillon Beach, California, a "semiprotected coastal habitat" (Hedgpeth 1962, Plate

¹Current address: Institute of Marine Science, School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, AK 99775-1080

1); 26 fish from Bodega Bay, California, a "protected coast"; and six fish from Pacifica, California, an "outer, wave swept coast". Fish were taken from the lower intertidal zone (Ricketts and Calvin 1968) during 99 low tide periods of -0.3 to -2.0 feet.

Collecting began in November 1981 and continued intermittently until July 1987. Data on standard (SL) and total (TL) length, weight, and gonads were obtained from fish caught by the first author and/or fishing partners. However, the fishermen scattered along the rocks usually filleted their catch there, so gonads were often not available. Because the first author could not be present at all fishing sites, different numbers of fish were used in the various analyses.

Otoliths (sagittae) were removed, cleaned, and stored dry in gelatin capsules. The small (± 3 mm diameter) otoliths are difficult to extract because the bones of the skull are very thick. The opercle was then evaluated as a structure for aging. The gill covers proved to be easy to dissect with a small wire clipper. Skin and flesh was removed after soaking in a hot solution of a protein-dissolving laundry product (BIZ®). Opercula had very clear growth marks and were stored dry in envelopes. Ages were determined by the second author using a Wild dissecting microscope at 25x and indirect lighting.

Because the otolith is a standard aging structure for marine fishes (Chilton and Beamish 1982), otoliths and opercula from 39 fish were compared to see whether they yielded the same age estimates. The results indicated that they were comparable, and so opercula were used as the standard aging structures. Estimates, using the von Bertalanffy equation of growth parameters, based on both structures from 91 specimens were made. The estimates L_{∞} , k , and t_0 were tested for significance for non-linear models with an F -test after Ratkowsky (1983).

Early in the study, only TL was measured and a conversion to SL was necessary. This was calculated from 177 observations for which both lengths had been measured. The linear regression is:

$$SL = TL (0.931) + 1.416$$

with an R^2 of 0.977.

The age-length data were compiled separately for males and females. Ages determined from opercula were used to estimate parameters of the von Bertalanffy growth model:

$$L_t = L_{\infty} [1 - e^{-kt_0}]$$

where L = length at age t ,
 L_{∞} = asymptotic length of the species,
 k = growth completion rate, and
 t_0 = theoretical age at zero length.

Weights were taken for 139 fresh fish ranging from 27 cm and 145 g to 60 cm and 1950 g. Using the equation:

$$W = aL^b$$

where W = weight in g,
 L = standard length in cm for males and females,

Table 1. Comparison of age estimates based on otoliths and opercula of 39 fish.

Age	n	% Agreement	%± 1yr.	%± 2 yrs.
4	2	100		
5	10	50	50	
6	9	55.6	22.2	22.2
7	5	60	40	
8	4		50	50
9	2	50		50
10	2	50		50
13	1		100	
14	2	50		50
16	2			100

resulted in estimates for the constants a and b. Log transformation of the data was performed in order to compare the linear regression statistics.

The number of ovaries obtained each month varied widely, depending on occurrence of low tides (< 0.3 ft) during daylight hours and surf conditions. Also, a major factor was the numbers of fishermen on the rocks during spring and summer months.

Gonads were removed from 196 females and brought to the laboratory to estimate the reproductive stage. Four developmental stages were noted on the basis of their characteristic color using Smithe's (1974) color guide. Immature gonads were pearl grey, maturing gonads contained eggs that were orange yellow or spectrum orange, ripe gonads contained eggs that were chrome orange and resting gonads were flacid and pearl grey.

Gonadal weights and estimates of fecundity of two fish were recorded using a Mettler balance and a dissecting microscope (12x), respectively. Testes from 22 males were collected. Immature testes were threadlike, whereas mature testes were swollen and white, while spent testes were grey-brown and roughly triangular in shape.

RESULTS AND DISCUSSION

The technique for age determination using otoliths is widely accepted and defined (Chilton and Beamish 1982). We followed standard aging techniques where one ring represented one year's growth. We found the otolith to have clear growth rings, but they were very small and were difficult to remove. The opercula were much easier to dissect, had equally clear growth rings, and age determination from the otoliths and opercular were similar. In 30 of 39 comparisons (77%), the two structures had ages either matching or within one year of each other (Table 1).

Growth curves compared from data on 91 fish were not significantly different ($F = 1.0891$, $df = 3,177$) (Table 2; Fig. 1). Estimated size at age was larger for males than females after age eight (Table 3; Fig. 2). Both sexes were aged up to 18 years

Table 2. von Bertalanffy growth model parameter estimates and standard deviations for monkeyface pricklebacks derived from 4 data sets. Comparisons of aging structures using the same data set and for males and females using all ages determined from the operculum.

Structure/Sex	Age (yr)	Length (cm)	L_{∞}	k	t_0	n
Otolith						
Est.	2-18	23-67	72	.10	-1.89	91
S.D.			8	.03	1.08	
Opercle						
Est.	2-18	23-67	71	.10	-2.63	91
S.D.			8	.04	1.31	
Opercle-Females						
Est.	0-18	15-62	62	.14	-1.95	115
S.D.			2	.02	.28	
Opercle-Males						
Est.	0-18	13-67	70	.12	-1.91	74
S.D.			5	.02	.29	

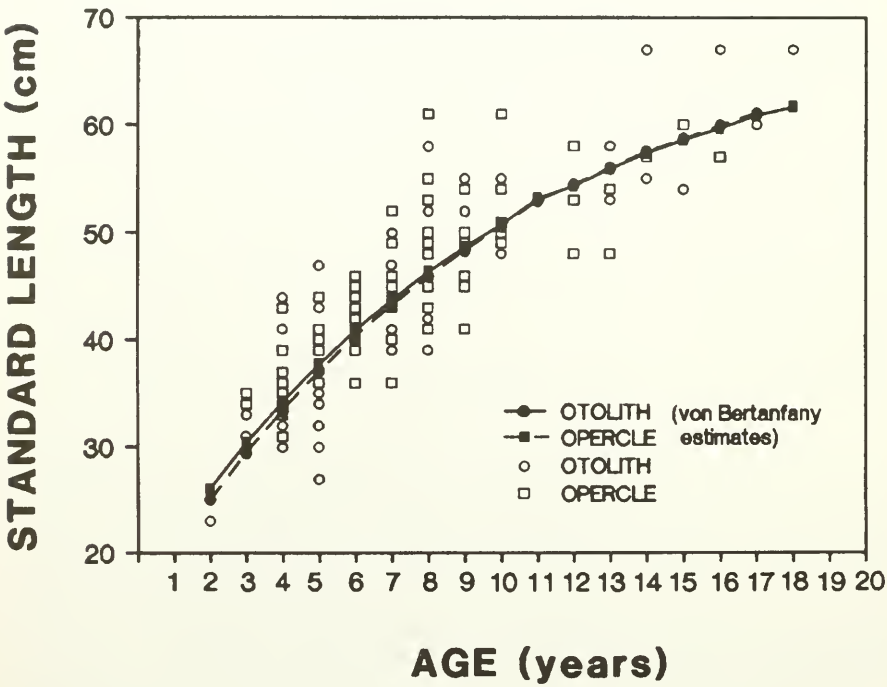


Figure 1. Comparison of growth rates of 91 monkeyface pricklebacks determined from otoliths and opercula.

Table 3. Estimated length at age from the von Bertalanffy growth equation for male and female monkeyface pricklebacks. The size range (CM SL) and numbers sampled of each age group are included.

Age	Males			Females		
	Mean size	Range	<i>n</i>	Mean size	Range	<i>n</i>
0	14	12-16	4	15	14-18	5
1	20	16-25	5	21	18-23	7
2	26	23	1	27	23	1
3	30	33	1	32	31-35	3
4	35	31-44	12	36	32-41	20
5	39	32-36	16	39	27-47	11
6	42	36-44	18	42	36-45	19
7	45	36-50	11	45	41-52	10
8	48	41-58	14	47	39-61	12
9	50	46-55	4	49	41-55	5
10	53	48-61	6	51	50-55	4
11	55	-	0	53	48	1
12	56	53-58	2	54	53-58	2
13	58	48-54	2	55	57-76	3
14	59	55-67	2	56	54-60	2
15	60	-	0	57	-	0
16	61	57-76	2	57	-	0
17	62	60	1	58	-	0
18	-	-		59	67	1
Totals			101			106

with maximum estimated standard lengths of 62 cm for females and 67 cm for males. Estimated length at age is presented in Table 3. Burge and Schultz (1973) presented ages for 12 specimens, which fall into the ranges of ages determined in this study.

Weight data for each sex were compared and the statistics were not significantly different ($P < 0.01$) (Table 4). These data were pooled with weight data on small fish (Edwards 1981) in order to construct a complete weight-length curve (Fig. 3). The 11 weights reported by Burge and Schultz (1973) and the three from Fitch and Lavenberg (1971) fall into the ranges obtained in this study.

Nineteen testes were examined. Eight were from immature males <25 cm, three swollen testes collected in May and June and eight spent testes were collected from May through July.

Fecundity was estimated for two females. One caught 5 February 1982 was seven years old, 41 cm SL, and contained approximately 17,500 mostly mature eggs. A second female caught on 12 March 1982 was 11 years old, 61 cm SL, and contained approximately 46,000 mostly mature eggs.

Examination of ovaries indicated that the sample consisted of 67 immature and 137 mature fish. Age at first maturity was four years (36 cm); 50% were mature at

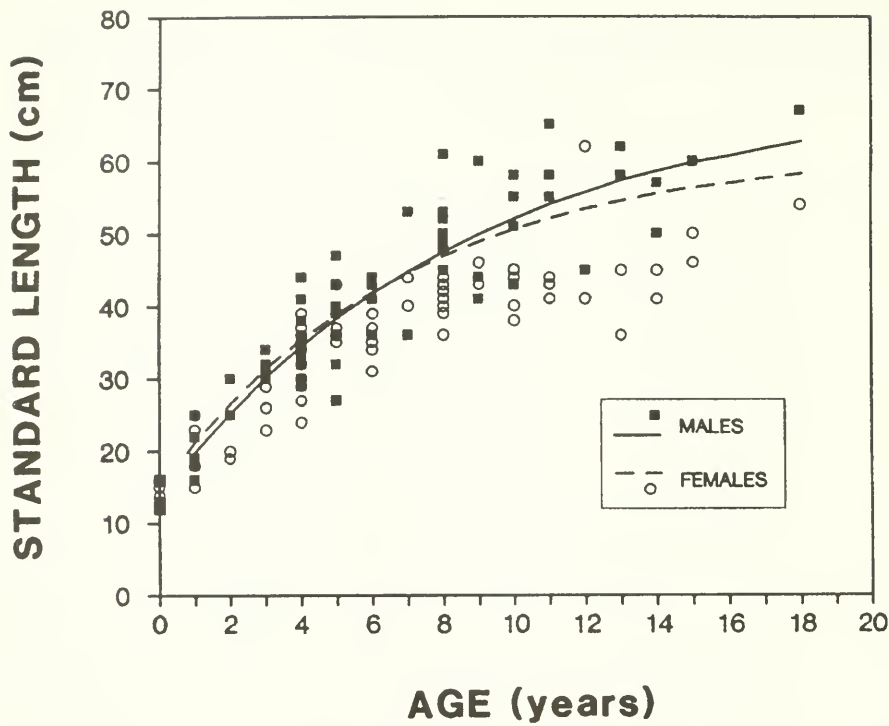


Figure 2. Comparison of growth rates of 171 male and female monkeyface pricklebacks determined from opercula.

Table 4. Weight at length parameters for males, females and for sexes combined from this study, and fish <20 mm from Edwards (1981), where $Weight = a(Length)^b$. Linear regression statistics for log transformed data where $\ln(Weight) = a(\ln Length) + b$. Growth curves for males and females are not significantly different ($P < 0.01$).

	a	b	n	r ²
<hr/>				
W + aL ^b				
Males	0.006797	3.072	62	
Females	0.0325	2.654	77	
Sexes Combined	0.01289	2.900	139	
This study plus				
Edwards (1981)	0.00965	2.971	174	
<hr/>				
$\ln W = b + a(\ln L)$				
Males	0.0735	3.382	62	0.90334
Females	0.0712	3.393	77	0.85512
Sexes Combined	0.0714	3.399	139	0.87767

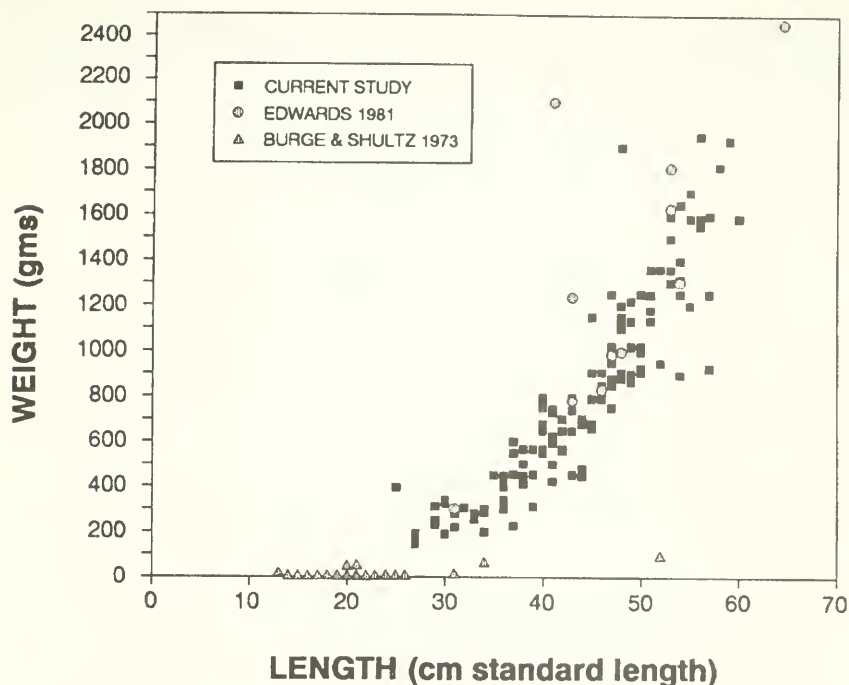


Figure 3. Weight-length relationships from this study and the literature.

five years (39 cm), and 100% were mature at seven years (45 cm). Reproductive activity began in January with the peak months of spawning in February, March and April.

Mature ovaries were collected March-May, maturing ones December-June, and spent ovaries February-August and one in December. The average age of 21 fish with mature ovaries dropped from 11 years (6) to 10 years (7), 8 years (6) and 6 years (2). This indicates that older fish spawned earlier than the younger ones. The small sample of testes indicates a similar pattern.

These data are similar to those reported on the Black Prickleback (*Xiphister atropurpureus*) by Wourms and Evans (1974). They suggest that this species, which also spawns in late winter and spring, are less apt to be exposed to environmental risks of wave shock, reduced salinity and high or low water temperatures.

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of 2 ovaries. Tad Deshler of U.C. Davis, supplied 26 fish that had been taken in Bodega Bay. Persons providing suggestions during field work were: W. L. Montgomery, Northern Arizona State University; M. H. Horn, California State University, Fullerton; M. Barton, Centre College of Kentucky; P. B. Moyle, University of California, Davis, and R. Methot, NMFS-Northwest Alaska Fisheries Center, Seattle, Washington. We thank V. Chow, U. C. Bodega Marine Laboratory and M. Horn for constructive comment on the manuscript.

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CHANGES IN DISTRIBUTION OF CACKLING CANADA GEESE IN AUTUMN

DENNIS G. RAVELING and DAVID S. ZEZULAK¹

Department of Wildlife and Fisheries Biology

University of California

Davis, CA 95616

Between autumns 1982 and 1988, the numbers of neck-banded cackling Canada geese (*Branta canadensis minima*) stopping in the lower Columbia River in Washington and Oregon and the Willamette Valley of Oregon increased from a trace to 25%+ of the total population. Concomitantly, proportions of neck-banded geese using the Klamath Basin of California declined from >70% to 51-62%. Proportions of marked geese migrating directly to the Sacramento Valley of California also varied significantly, averaging (unweighted) 7.7% (range = 3.6-10.1%). Although a tradition of cackling geese stopping and staying in Washington and Oregon was established, it was weak (0.272 probability of returning to Washington and Oregon) compared with the tradition to return to the Klamath Basin (0.732 probability of return to the Klamath Basin). The addition of cackling geese, a protected subspecies, in Washington and Oregon will further complicate harvest regulations because of the mixture of at least 5 different subspecies of Canada geese in this region. Continuation of the trend to use Washington and Oregon could result in California losing much of its cackling goose population.

INTRODUCTION

Estimated numbers of cackling Canada geese (hereafter, cackling goose) in the Pacific Flyway declined from about 350,000 in the 1960's to about 30,000 by 1983 (O'Neill 1979, Raveling 1984, King and Derksen 1986). From 1982-83 through 1988-89 we studied the distribution, behavior, and survival of cackling geese in winter based on sightings of individually identifiable neck-banded geese. During the study, an increasing proportion of the cackling goose population stopped and sometimes remained in the lower Columbia River of southwestern Washington and Willamette River Valley of western Oregon (W/O).

Distributions of many Canada goose populations have shifted, primarily to the North, from their previous winter ranges (Krohn and Bizeau 1988). Such "short-stopping" has been hypothesized to result from increased habitat and forage availability farther north (Crider 1967, Hankla and Rudolph 1967), differential survival of population subunits using different areas (Crissey 1968, Raveling 1978), or both of the above factors operating simultaneously (Malecki and Trost 1986, Hestbeck and Malecki 1989). Concern over changing distributions of Canada geese

¹Present address: California Department of Fish and Game, 1701 Nimbus Road, Suite A, Rancho Cordova, CA 95670

has resulted in a variety of management attempts to alter distribution through transplantation, hazing, and habitat manipulation on National Wildlife Refuges (NWR) which have not been successful (Hankla 1968) except where populations were reduced by harvest and not by changing migration habits (Rusch et al. 1985). The purpose of this paper is to report observations of marked cackling geese in relation to total population distribution and traditions of return to previously used autumn locations. Hunting of cackling geese has been prohibited since 1984, so results are not confounded greatly by this variable, although some cackling geese were still killed after the prohibition went into effect.

METHODS

Most geese were marked in autumn in California during 1982 (75.8% of 931), 1983 (84.1% of 699), and 1984 (77% of 512), with the remainder being marked on the Yukon Delta NWR of Alaska in late July-early August (see Raveling and Zezulak 1991 for details). From 1985 on, all geese were marked in Alaska (1985, 585; 1986, 406; 1987, 502; 1988, 345). Neck-bands were yellow with 3-digit, black, alpha-numerical codes (see Raveling et al. 1990 for details). Marked geese were observed with telescopes.

One full-time University of California, Davis (UCD) observer with assistance from California Department of Fish and Game (CDFG), U.S. Fish & Wildlife Service (FWS), and volunteers recorded cackling geese on an almost daily basis in California during 1982-83 and 1983-84 with brief (3-4 day) trips to Oregon. Two or three full-time UCD staff with assistance from agency and private personnel searched for marked geese on an almost daily basis from 1984-85 through 1986-87, including trips to W/O. In 1987-88 and 1988-89, the program was primarily conducted by FWS staff throughout the winter range of the cackling goose with a reduced but still substantial (i.e., >5,000 observations per year of marked individuals) effort by UCD and volunteer personnel. Efforts were concentrated at Tulelake NWR (41°56'N, 121°3'W) in California from the arrival of geese in mid-late October through November, coupled with visits to W/O, and the Sacramento Valley (SV) of California where volunteers and agency personnel also contributed observations of marked geese.

Data in this report refer to the first location of marked individuals observed in late October through November. Marked individuals were seen an average of 17 times during winter, usually with multiple sightings at the first location used in autumn. We included observations through 5 December for W/O as field efforts in these locations were less frequent and often began later than in California. Effort by the FWS in W/O was intensified from 1985 on as part of a program concentrating on recording neck-banded dusky Canada geese (*B. c. occidentalis*). First observations of marked geese were noted as being in W/O, the Klamath Basin (KB) of California (mostly the Tulelake NWR), the SV, mostly on or near the Sacramento NWR complex, and in an unknown (UNK) location. Unknown geese were those birds not seen in autumn but known to be alive because they were observed after 5 December.

Data from geese marked in California were excluded from the analyses for the year in which they were marked to avoid a bias of weighting too heavily those birds with a tradition of arrival to California. Some of these may also have stopped first in W/O but could not be recorded as they were not yet marked. Proportions of California banded geese seen in the year after banding in different locations were compared (χ^2 tests) to proportions of Alaska banded geese seen in those same locations. Other comparisons among locations and age-sex categories were also tested with Chi-square contingency tables.

RESULTS

Autumn Distribution

The proportions of adult males and females banded in Alaska that were first seen in different locations on the winter range did not vary significantly in 1982 and 1984-1988 (all P 's > 0.4), so data from adult sex classes were combined in each year, including 1983 when sample sizes were too small for testing. In 1982 and 1984, the tests compared proportions seen in KB vs. all other locations combined (W/O, SV, and UNK) because sample sizes seen in these other locations were too small for confident testing by individual area. Sample sizes from 1985 through 1988 allowed testing of proportions of adult sexes across all individual areas (W/O, KB, SV, and UNK).

The proportions of marked geese seen in KB vs. other locations in 1983 did not differ significantly among birds marked in California or Alaska in 1982 ($\chi_1^2 = 2.41$, $P > 0.1$), nor did the total sample of 1982 banded geese seen in 1983 differ significantly in distribution from sightings of adult geese banded in Alaska in 1983 ($\chi_1^2 = 0.10$, $P > 0.7$). The total sample of geese banded in 1983 seen in KB vs. other locations in 1984 approached a significant difference from the distribution of adults banded in Alaska 1984 ($\chi_1^2 = 3.77$, $P = \text{slightly} > 0.05$). Proportions of geese banded before 1985 did not differ significantly in their distributions among W/O, KB, SV, and UNK in 1985 from adult geese banded in Alaska in 1985 ($\chi_3^2 = 0.64$, $P > 0.8$). Based on these results, sightings of geese banded in California in 1982, 1983, and 1984 were combined for analyses with newly banded geese from Alaska in the years following their banding in California.

The proportions of immatures banded in summer in Alaska seen in KB vs. all other locations combined in the autumn after banding did not vary significantly from the distribution of adults in 1982 ($\chi_1^2 = 0.66$, $P > 0.3$) nor did proportions of age classes seen in W/O, KB, SV, and UNK in the autumn after banding in 1987 ($\chi_3^2 = 3.20$, $P > 0.3$) or 1988 ($\chi_3^2 = 0.73$, $P > 0.8$). Distribution in autumn of immatures banded during summer did vary significantly in proportions seen in KB vs. other locations combined in 1983 ($\chi_1^2 = 15.37$, $P < 0.001$) and 1984 ($\chi_1^2 = 10.04$, $P < 0.01$), and proportions of immatures banded in 1985 and 1986 seen in W/O, KB, SV, and UNK varied significantly from proportions of adults in those same areas (1985, $\chi_3^2 = 12.57$, $P < 0.01$; 1986, $\chi_3^2 = 12.33$, $P < 0.01$).

The proportions of marked cackling geese that used each major location compared with proportions in other locations varied significantly across the years of the study (W/O - combining 1982 and 1983 because of small samples in W/O in those years [Table 1], $\chi^2_5 = 117.72$, $P < 0.0001$; KB - $\chi^2_6 = 121.06$, $P < 0.0001$; SV - $\chi^2_6 = 28.02$, $P < 0.0001$; UNK - $\chi^2_6 = 92.60$, $P < 0.0001$). The major differences were related to increased numbers of marked geese in W/O from 1984 on, decreasing numbers in the KB, variable but mostly larger numbers in SV in later years, and variable proportions in UNK locations.

Results for 1982, 1983, and, to a lesser degree, 1984 may underestimate proportions in W/O and possibly SV and thereby inflate proportions in KB because of fewer personnel and consequently less effort in W/O and SV than in subsequent years. Therefore, proportions of marked geese first seen in different regions were compared from 1984 through 1988 and 1985 through 1988. Again, proportions using each area varied significantly along the same trends noted above when comparing all years (W/O-1984-88, $\chi^2_4 = 39.86$, $P < 0.001$; 1985-88, $\chi^2_3 = 9.25$, $P < 0.05$; KB-1984-88, $\chi^2_4 = 87.34$, $P < 0.0001$; 1985-88, $\chi^2_3 = 57.77$, $P < 0.0001$; SV-1984-88, $\chi^2_4 = 15.40$, $P < 0.01$; 1985-88, $\chi^2_3 = 14.69$, $P < 0.01$; UNK-1984-88, $\chi^2_4 = 85.34$, $P < 0.0001$; 1985-88, $\chi^2_3 = 76.57$, $P < 0.0001$). In summary, there was a shift of geese from KB to W/O along with more geese going on past KB to SV in some years. The higher proportions of geese in UNK in 1982 and 1983 probably reflected the lower effort in those years, especially in W/O where some of those geese may have stopped (see below). The relatively high proportion of geese not seen in autumn 1987 occurred in the year of reduced effort by UCD staff and transfer of responsibility for monitoring to the FWS.

The proportions of immature geese using KB were lower than proportions of adults using KB in all years in which there were significant differences in the distribution of the two age classes, especially in 1983 and 1984 (Table 2). The total sample sizes for immatures, however, were relatively small compared with the sample sizes of adults, and, thus, the general pattern was not highly skewed by combining all age-sex classes (in Table 1) even though significant differences between age classes existed from 1983 through 1986 (Table 2). A higher proportion of immatures than adults used W/O in 1984 and 1985 (but fewer in 1986) or overflowed KB to SV in 1984. Higher proportions of immatures compared to adults were in UNK locations in 1983, 1985, and 1986. Because of the intensive effort in KB, most of those geese in UNK locations were probably in W/O and, to a lesser degree, SV. Thus, the increasing proportions of cackling geese using W/O that began in 1984 and 1985 were related to a differential migration pattern of age classes with families stopping in W/O with proportionally more adults without young continuing on to KB. In 1984, more flocks with a higher proportion of immatures also went directly to SV.

The suggestion that most geese not seen in autumn were probably in W/O and SV where effort was less intense and often began later than in KB is supported by subsequent sightings later in winter of these geese (Table 3). Many of those geese not seen until March-April in northeastern California were also likely to have been in W/O earlier in the winter, as we have numerous records of geese seen in autumn

Table 1. Distribution of first sightings of neck-banded cackling Canada geese in Autumns 1982-88.

Location ^c	1982 ^a		1983 ^{a,b}		1984 ^{a,b}		1985 ^b		1986 ^b		1987		1988		Totals	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
W/O	3	2.5	3	0.8	40	7.2	147	15.8	166	18.6	121	13.5	141	16.9	621	13.4
KB	82	67.2	289	74.5	390	70.5	632	67.9	507	56.9	455	50.6	487	58.3	2842	61.5
SV	8	6.6	14	3.6	53	9.6	51	5.5	82	9.2	9	10.1	72	8.6	371	8.0
UNK ^c	29	23.8	82	21.1	70	12.7	101	10.9	136	15.3	232	25.8	136	16.3	786	17.0
No.=	122		388		553		931		891		899		836		4620	

^a Includes only those geese banded before that autumn.^b See text and Table 2 for differences between age classes.^c W/O = Washington/Oregon; KB = Klamath Basin, California; SV = Sacramento Valley, California; UNK = unknown.

Table 2. Distribution of first sightings of adult and immature cackling Canada geese in Autumn.

Location ^a	Age	1983		1984		1985		1986	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
W/O	Adult	3	0.9	32	6.4	122	15.0	139	19.8
	Immature	0		8	14.8	25	21.6	27	14.4
KB	Adult	267	76.5	362	72.6	566	69.5	408	58.0
	Immature	22	56.4	28	51.9	66	56.9	99	52.7
SV	Adult	12	3.4	40	8.0	47	5.8	63	9.0
	Immature	2	5.1	13	24.1	4	3.5	19	10.1
UNK	Adult	67	19.2	65	13.0	80	9.8	93	13.2
	Immature	15	38.5	5	9.3	21	18.1	43	22.9
No. =	Adult		349		499		815		703
	Immature		39		54		116		188

^a W/O = Washington/Oregon; KB = Klamath Basin, California; SV = Sacramento Valley, California; UNK = unknown.

Table 3. Neck-banded cackling Canada geese subsequently sighted in the same winter after being in unknown (UNK) locations during Autumn, Pacific Flyway, 1982-89.

Location	<i>n</i>	%
Washington/Oregon	251	31.9
Klamath Basin	44	5.6
Central Valley ^a	303	38.6
N.E. CA in spring	140	17.8
Remained Unknown	48	6.1
Totals	786	100.0

^a Sacramento plus San Joaquin Valleys of California combined, as later in winter many cackling geese move to the latter region but there were none present in autumn.

or midwinter in W/O that came to northern California during late-winter and spring (unpubl. data). Only a relatively small proportion (6.1%, Table 3) of geese not seen in autumn that were known to be alive from subsequent observations in later years were not seen at all during a winter. In summary, proportions of cackling geese using W/O and SV were larger than indicated in Table 1 because many of the geese not seen in autumn were no doubt present in these locations.

Table 4. Number (%) of Canada Geese seen only in Washington/ Oregon and in both Washington/Oregon and California during winter, 1982-89.

Year	Location		Totals
	Only in W/O ^a	W/O and CA	
1982-83	3	1	4
1983-84	7	4	11
1984-85	28 (58.3)	20 (41.7)	48
1985-86	136 (63.3)	79 (36.9)	215
1986-87	127 (57.7)	93 (42.3)	220
1987-88	170 (73.0)	63 (27.0)	233
1988-89	155 (76.4)	48 (23.7)	203

^a Washington/Oregon

Use of W/O All Winter

In addition to more cackling geese stopping in W/O from 1984 on, a significantly higher proportion was seen only in W/O when testing 1984 through 1988 ($\chi^2 = 23.34$, $P < 0.001$), being most pronounced in the winters of 1987-88 and 1988-89 (Table 4). Thus, a tradition of both stopping and staying at W/O seems to be established involving perhaps more than 20-25% of the total population (Table 1 sightings plus considering that 1/3 or more of geese in UNK locations were probably in W/O [Table 3]).

Year-to-year Distributions

Geese seen in W/O from 1984 through 1987 did not vary significantly ($\chi^2 = 4.08$, $P > 0.1$) in proportions returning to W/O vs. other locations in the subsequent years (Table 5). An overall unweighted average of 25.5% of geese that used W/O returned to W/O in the subsequent year. The proportions of geese seen in W/O from 1984 through 1987 that went to the KB in the subsequent year (1985 through 1988) did not vary significantly ($\chi^2 = 2.90$, $P > 0.3$) and averaged (unweighted) 51.1%. Samples of geese seen in W/O that went to the SV in a subsequent year were too small for testing and averaged (unweighted) 5.0%. The proportions of geese seen in W/O in 1984 through 1987 that were in an UNK location in the subsequent year (1985 through 1988) varied among years ($\chi^2 = 9.64$, $P < 0.05$), but not in a consistent pattern (Table 5) and averaged (unweighted) 18.3%. Thus, geese stopping in W/O had a fairly weak tradition of returning to W/O in the subsequent year, even allowing for those in UNK actually being in W/O, and the majority went to the KB after a previous autumn stop in W/O.

Samples of geese seen in KB in 1982 through 1987 were large enough to test across all years (seen again in the subsequent year, 1983 through 1988). The proportion of geese seen in KB that used W/O in a subsequent year varied significantly across all years ($\chi^2 = 19.81$, $P < 0.01$), being lowest during 1983 and

Table 5. Year-to-year distribution of cackling Canada geese in Autumns 1982-87.

Year	Seen at	n	No. (%) of same geese seen subsequent year at:			
			W/O ^a	KB ^a	SV ^a	Unk ^a
1982	W/O					
	KB	208	21 (10.1)	156 (75.0)	7 (3.4)	43 (20.7)
	SV	4		4		
	UNK	10		8		2
1983	W/O	1		1		
	KB	303	17 (5.6)	235 (77.6)	25 (8.3)	26 (8.6)
	SV	8	2	3	2	1
	UNK	71	9 (12.7)	41 (57.8)	4 (5.6)	17 (23.9)
1984	W/O	23	4 (17.4)	13 (56.5)	2 (8.7)	4 (17.4)
	KB	387	56 (14.5)	272 (70.3)	20 (5.2)	39 (10.1)
	SV	31	3 (9.7)	21 (67.7)	5 (16.1)	2 (6.5)
	UNK	48	8 (16.7)	32 (66.7)	2 (4.2)	6 (12.5)
1985	W/O	120	35 (29.2)	66 (55.0)	4 (3.3)	15 (12.5)
	KB	332	52 (15.7)	214 (64.5)	28 (8.4)	38 (11.5)
	SV	27	4 (14.8)	18 (66.7)	2 (7.4)	3 (11.1)
	UNK	67	16 (23.9)	28 (41.8)	6 (9.0)	17 (25.4)
1986	W/O	95	21 (22.1)	42 (44.2)	5 (5.3)	27 (28.4)
	KB	286	32 (11.2)	175 (61.2)	28 (9.8)	51 (17.8)
	SV	46	1 (2.2)	24 (52.2)	12 (26.1)	9 (19.6)
	UNK	73	12 (16.4)	34 (46.6)	3 (4.1)	24 (32.9)
1987	W/O	78	26 (33.3)	38 (48.7)	2 (2.6)	12 (15.4)
	KB	236	25 (10.6)	152 (64.4)	19 (8.1)	40 (17.0)
	SV	53	8 (15.1)	34 (64.2)	6 (11.3)	5 (9.4)
	UNK	188	40 (21.3)	94 (50.0)	16 (8.5)	38 (20.2)

^a W/O = Wash./Ore.; KB = Klamath Basin, California; SV = Sacramento Valley, California; UNK = unknown.

1984 (unweighted = 7.8%) and increasing to a mean (unweighted) of 13.0% from 1985 through 1988. However, less effort in W/O may have affected results in 1983 and 1984 and proportions of geese seen in KB from 1984 through 1987 that used different locations in 1985 through 1988 did not differ significantly ($\chi^2_3 = 4.67$, $P > 0.1$).

The proportions of cackling geese seen in KB that returned to KB in the subsequent year varied significantly across all years ($\chi^2_5 = 27.66$, $P < 0.0001$) but not from 1985 through 1988 ($\chi^2_3 = 6.56$, $P > 0.05$) nor 1986 through 1988 ($\chi^2_2 = 0.86$, $P > 0.5$). Probability of returning to KB was 74.3% (unweighted) from 1983-85 and

63.4% (unweighted) from 1986-88, illustrating the weakened tradition of return to KB. However, the tradition of returning to KB was much higher than the tradition of returning to W/O.

The proportions of cackling geese seen in KB that went to the SV in a subsequent year varied significantly across all years ($\chi^2_5 = 11.28$, $P > 0.05$) but not from 1985 through 1988 ($\chi^2_3 = 5.57$, $P > 0.05$) nor from 1986 through 1988 ($\chi^2_2 = 0.57$, $P > 0.7$). The proportion of geese shifting from KB to SV in a subsequent year averaged (unweighted) 5.6% from 1983-85 and 8.8% from 1986 through 1988. Thus, some of the lower proportions of geese returning to KB after 1985 went directly to SV as well as to W/O.

The proportions of geese seen in KB that were in an UNK location in a subsequent year varied significantly across all years ($\chi^2_5 = 27.48$, $P < 0.001$) as well as from 1985 through 1988 ($\chi^2_3 = 12.05$, $P < 0.01$). The proportions in UNK were highest in 1983 when our effort was less, and in 1987 when our effort was reduced as the FWS effort was in transition. The proportions of geese at KB in 1987 that were in an UNK location in 1988 also remained relatively high (Table 5).

Proportions of cackling geese seen in SV during 1984 through 1987 that used W/O, SV, or UNK locations in subsequent years (1985 through 1988) were too small to permit testing. The overall unweighted average proportions of geese seen in SV that used W/O, SV, and UNK in a subsequent year were 10.5%, 15.2%, and 11.7%, respectively. Thus, there was only a weak tradition of return to SV in subsequent years. The proportions of geese using SV in 1984 through 1987 that used the KB in subsequent years (1985 through 1988) did not vary significantly ($\chi^2_3 = 2.66$, $P > 0.2$) and averaged (unweighted) 65%, which was as strong a probability ($\chi^2_1 = 0.85$, $P > 0.3$) as geese that had used and then returned to KB in those years.

Proportions of geese in an UNK location in 1983 through 1987 that used W/O in a subsequent year (1984 through 1988) did not vary significantly ($\chi^2_4 = 3.99$, $P > 0.3$) and averaged (unweighted) 18.2%. Proportions of geese in UNK that subsequently used KB or UNK also did not vary significantly ($\chi^2_4 = 8.92$, $P > 0.05$; $\chi^2_4 = 8.12$, $P > 0.05$, respectively) and averaged (unweighted) 52.6% and 23.0%, respectively. Proportions of geese in an UNK location in 1983 through 1987 that were subsequently seen in SV (1984 through 1988) were too small for testing and averaged (unweighted) 5.3%. In summary, regardless of where cackling geese were in the autumn of a given year, the largest proportion of them used KB in the subsequent year.

Because there was only one significant difference in proportions of geese seen from 1984 through 1987 using different locations in subsequent years (1985 through 1988), and that was for birds in an UNK location, the average probability of geese returning to, or shifting among, regions can be summarized as in Table 6. The proportions of geese using W/O, KB, and SV that returned in a subsequent year to those locations varied significantly among regions ($\chi^2_4 = 63.53$, $P < 0.0001$). Geese using KB had a higher probability of returning to KB (0.655) and a lower probability of returning to W/O (0.133) than did geese using W/O that subsequently returned to W/O (0.272) or to the KB (0.503). The probability that geese using KB returned to KB was 2.4 times (0.655/0.272) greater than the probability of geese using W/O

Table 6. Summary of Probabilities of Cackling Canada Geese Returning to the Same or Different Locations from 1985 through 1988 (from Locations in 1984 through 1987; Data from Table 5).

Location ^a in 1984 through 1987	n	No. (%) returning in subsequent year (1985 through 1988) to:			
		W/O	KB	SV	UNK
W/O	316	86 (27.2)	159 (50.3)	13 (4.1)	58 (18.4)
KB	1241	165 (13.3)	813 (65.5)	95 (7.7)	168 (13.5)
SV	157	16 (10.2)	97 (61.2)	25 (15.9)	19 (12.1)
UNK	376	76 (20.2)	188 (50.0)	27 (7.2)	85 (22.6)

^a W/O = Wash./Ore.; KB = Klamath Basin, California; SV = Sacramento Valley, California; UNK = unknown.

returning to W/O, but only 1.3 times greater than the probability of geese using W/O going to KB the subsequent year. Thus, while numbers of geese increased in W/O, little of the increase involved return of the same geese from year to year.

DISCUSSION

Although the numbers of cackling geese using W/O in 1982, 1983, and, perhaps, 1984 may have been underestimated because of less effort in those years, the bias may not be large. Biologists studying Canada geese in W/O (R. L. Jarvis, Oregon State Univ.; J. E. Cornely and M. R. Hills, [FWS]) believe that numbers of cackling geese in W/O increased beginning in 1984 and, especially, 1985 (pers. comm.). Of 2,957 recoveries in the lower 48 states of cackling geese banded in California between 1952 and 1978, 94.9% were from California, 0.9% from Washington, and 4.0% from Oregon (Pacific Flyway Management Plan for Cackling Canada Geese, 1986, prepared for Pacific Flyway Council). Prior to 1984 and 1985, there were dramatic changes in the numbers of other subspecies of Canada geese, especially the dusky and Taverner's (*B. c. taverneri*) in W/O, but the cackling goose was considered an uncommon transient (Simpson and Jarvis 1979, Havel and Jarvis 1988, Jarvis and Cornely 1988). We conclude that the proportions of neck-banded cackling geese seen in W/O from 1984 through 1988 represent a real change in autumn distributions. The total population of cackling geese increased to about 60,000 in 1988 (unpubl. data). If about 31.9% of marked geese in an UNK location in autumn were in fact in W/O (Table 3), then the total proportion of marked cackling geese in W/O in 1988 was 38% ($0.333 \text{ seen in W/O} + [0.319 \times 0.154 - \text{the proportion in UNK expected to be in W/O}]$; Table 5). Thus, the numbers of cackling geese stopping in W/O in 1988 were about 22,800 ($60,000 \times 0.38$).

The change in distribution occurred fairly rapidly during a period when harvest of cackling geese was illegal (although some were killed). The change probably occurred too rapidly for the differential survival of cackling geese using W/O vs. California to have been a major factor, although differential survival may become

a contributing factor now that some tradition for using W/O has been established. Although we analyzed seasonal and annual survival rates for marked cackling geese (Raveling et al. unpubl.), sample sizes of geese were too small to confidently test for differences in survival between geese that were seen only in W/O vs. those seen in California. Such tests may become feasible soon if population size in W/O continues to increase and neck-banding and observation efforts continue. Avian cholera is common in California (e.g., Rosen 1971, McLandress 1983) and kills hundreds, if not thousands, of cackling geese in at least some years (Raveling and Zezulak 1991). Thus, losses to disease plus other agents in California could conceivably result in a continuing increase of cackling geese in W/O.

The most obvious feature associated with increased use of W/O by cackling geese was that proportions of immatures seen in autumn 1984 and 1985 in W/O were greater than those for adults and the reverse occurred in KB. Although cackling geese rarely maintain close family organization during winter (Johnson and Raveling 1988), our continuing observations suggest that families arrive in KB intact but separate within a few days. This suggests that a disproportionate number of families stopped in W/O whereas non- and failed breeding adults tended to continue to California. Such a result could be related to a weaker ability of smaller and still growing immatures to continue migrating compared with the stronger ability of adults, especially those without young which would molt earlier than brood adults (although a disproportionate number of immatures also went to SV as well as to W/O in 1984). Cooch (1961) found that lesser snow geese (*Anser caerulescens caerulescens*) interrupted autumn migration more frequently in more locations in years following a late spring snow-melt when nesting was delayed and development of immatures was late compared with years of early hatch and subsequent greater body mass in autumn. The differential use of W/O by immatures in some years also means that indices of population age structure obtained in early autumn in KB from trap samples or plumage identification (see Raveling and Zezulak 1991) may underestimate the proportion of young in the total population in those years.

The sample of marked cackling geese available, coupled with continued marking of geese, offers the opportunity to quantify changes in distribution of known individuals if the trend for increasing numbers of cackling geese to stop and stay in W/O continues. Such a phenomenon will further complicate harvest regulations and hunter opportunity because of the mix of subspecies in W/O. More research into methods of censusing the number of cackling geese in W/O would be useful to monitor population shifts and the status of this and other subspecies using W/O.

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THE USE OF HIGH-CUT STUMPS BY BIRDS

MICHAEL L. MORRISON

Department of Forestry and Resource Management
University of California
Berkeley, CA 94720

The deterioration of short snags or "high-cut stumps" and their use for foraging and nesting by birds were evaluated in the Sierra Nevada between 1984-85 and 1990. Pine stumps deteriorated more rapidly than fir, although the majority of bark was still present after 5-6 years on all species. All conifer species except incense-cedar were heavily used for foraging by birds; however, few nests were excavated in any species of high-cut stump. Almost all stumps showed some sign of arthropod activity. Although high-cut stumps do not serve as adequate replacements for taller snags, they do provide useful foraging and occasional nesting locations in areas where tall snags pose safety hazards or interfere with silvicultural activities. Incense-cedar should not be used, and fir and pine should be emphasized, when creating high-cut stumps.

INTRODUCTION

The use of standing dead trees, or snags, by wildlife is well documented. All Classes of vertebrates have some species that use snags for denning and breeding, as well as feeding substrate because of the arthropod food found in and under the bark (e.g., Thomas et al. 1979, Davis et al. 1983, Raphael and White 1984). Controversy exists, however, over the density and size of snags needed in an area to support populations of snag-dependent wildlife. This controversy occurs because snags occasionally pose fire hazards, interfere with the operation of ground and aerial forestry equipment, and cause property damage or personal injury when they fall near roads, trails, or buildings (see Morrison et al. [1983, 1986] for reviews).

The creation of "high-cut stumps" has been proposed as one way of eliminating some of the safety hazards caused by snags in certain areas, while still providing some shelter, food substrate, and possibly even nesting sites for wildlife (Kroll et al. 1980, Morrison et al. 1983). "High-stumping" creates snags that are short (usually 1-2 m) compared to most natural snags, less hazardous than taller snags, and result in little loss of timber revenue when created from living trees (Morrison et al. 1983). Trees are usually cut at or near ground level during timber harvest.

Morrison et al. (1983) reviewed the use by birds of natural snags in relation to snag height, and they found that about 90% of all cavity-nesting bird species nested in snags >2 m tall. No information was available on the use of stumps for foraging. They recommended that experimental creation of high-cut stumps be initiated to help clarify their use by wildlife. This paper is a follow-up to Morrison et al.'s review and presents original data on the use of high-cut stumps for nesting and feeding by birds.

STUDY AREA

The study area was the University of California's Blodgett Forest Research Station, El Dorado County, California. The 1,200 ha forest (1,200-1,450 m elevation) is in the mixed-conifer zone (Griffin and Critchfield 1972) of the western Sierra Nevada. Predominant tree species are incense-cedar (*Calocedrus decurrens* [Torr.] Florin.), white fir (*Abies concolor* [Gord. & Glend. Lindl.], sugar pine (*Pinus lambertiana* Dougl.), ponderosa pine (*P. ponderosa* Dougl. ex Laws), Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), and California black oak (*Quercus kelloggii* Newb.). The forest was primarily mature (i.e., >70 years old and >30 cm diameter breast height) second-growth timber divided into 5- to 40-ha compartments and managed under different silvicultural systems. See Morrison et al. (1987) for a more detailed description of Blodgett Forest.

METHODS

Within the guidelines given below, the specific location, spacing, and species composition of each group of stumps was left to the discretion of the forestry operator for logistical and safety reasons and have results with practical application.

High-cut stumps were made with a chainsaw during regularly-scheduled forest operations in mature stands and along the edges of clear-cuttings. Sample sizes were inadequate to divide analyses by stand type. The chainsaw was held as high on the trunk as safety considerations allowed on the uphill side of the slope; no ladder or other support was used to stand above the ground. Bull (1978) and Evans and Conner (1979) indicated that snags in groups are used preferentially to scattered individuals. Therefore, stumps were made in groups of 2-6, although 70% were in groups of 4 (our prescribed goal); stumps in a group were within 10 m of each other. An attempt was made to select different species of trees for each group depending upon the species composition of a site. However, because of their sparse and irregular distribution, oaks were not used for high-stumping. The largest (by diameter) trees present were selected for high-stumping to maximize the chances that birds would use them for nesting and feeding (Mannan et al. 1980, Raphael and White 1984). One group was created in about every 5 ha of forest.

Stumps ($n = 29$ groups and 114 individuals) were created between June 1984 and March 1985. Each stump was individually marked with a numbered tag, and the following data were recorded within 1 month of creation: group and tag number; tree species; diameter at breast height (dbh) or diameter at top of stump if under dbh; height; percent bark cover (visual estimate); hardness (subjective scale from 1 [hard] to 5 [soft] based on observer's ability to thrust a knife into the bark); evidence of feeding activity (i.e., woodpecker excavations); and number of nest cavities. Because only living trees were cut, all stumps began at hardness category 1. Notes were taken on evidence of arthropod activity and fungal decay. Stumps were resurveyed in September 1990 and these same data were recorded. June 1984 to March 1985 data were lumped for comparisons with the September 1990 resurvey.

Table 1. Hardness rating (1 = hard; 5 = soft) in 1990 of high-cut stumps created in 1984-85, western Sierra Nevada, California.

Species	No. of stumps	Hardness rating (%)				
		1	2	3	4	5
Douglas-fir	29	79	21			
White fir	19	95			5	
Sugar pine	21	52	19	19	10	
Ponderosa pine	32	38	28	22	13	
Incense-cedar	13	92	8			
Total fir ^a	48	85	13		2	
Total pine ^a	53	43	25	21	11	
Total conifer ^a	114	67	18	10	6	

^aTotal fir = Douglas-fir and white fir; total pine = sugar and ponderosa pines; total conifer = all species combined.

Changes in stump characteristics were compared using *t*-tests for paired comparisons (Sokal and Rohlf 1969:328-333).

RESULTS

No significant ($P > 0.5$, *t*-test) differences were found in dbh or height for any species of stump between 1984-85 and 1990. Overall (all species combined) average dbh was 62 cm (SD = 15.4) and height was 145 cm (20.6).

Overall, 34% of the stumps declined from hardness class 1 to hardness classes 2-4 between sampling periods; most (18%) of this decline was to class 2 (Table 1). Among species, most white fir and incense-cedar remained as class 1, and 21% of the Douglas-fir declined to class 2. Almost half of the sugar pine and two-thirds of the ponderosa pine, however, declined to classes 2-4. Thus, only 15% of the total "fir" (combining true fir and Douglas-fir) declined, whereas 57% of the total pine (combining sugar and ponderosa pines) declined in hardness.

Overall, about two-thirds of all stumps showed signs of woodpecker feeding. No other wildlife use was noted. All tree species except incense-cedar showed woodpecker feeding on greater than 50% of the stumps, ranging from a low of 53% for white fir to 75% for ponderosa pine (Table 2). Only 31% of incense-cedar stumps showed signs of woodpecker foraging. Overall by species group, total fir showed slightly less (63% versus 72%) feeding activity than total pine. The sizes and shapes of holes on the bark surface indicated that woodpeckers were excavating into the stumps to remove wood-boring insects such as beetles.

Four nest holes were found: 2 in ponderosa pine, and 1 each in Douglas-fir and sugar pine. The bird species creating the excavations were unknown, but hole sizes indicated white-headed woodpeckers (*Picoides albolarvatus*) may have created the

Table 2. Evidence of feeding by woodpeckers in 1990 on high-cut stumps created in 1984-85, western Sierra Nevada, California.

Species ^a	No feeding (%)	Feeding (%)
Douglas fir	31	69
White fir	47	53
Sugar pine	33	67
Ponderosa pine	25	75
Incense-cedar	69	31
Total fir	38	63
Total pine	28	72
Total conifer	37	63

^aSpecies, species categories, and sample sizes defined in Table 1.

cavities, with possible secondary use by mountain (*Parus gambeli*) or chestnut-back (*P. rufescens*) chickadees.

There was a small (13%) but significant ($P < 0.001$) change in bark cover for all species combined between sampling periods (Table 3). By species, the change in bark cover was only 1-5% for incense-cedar, white fir, and Douglas-fir, although the change for Douglas-fir was significantly different ($P = 0.016$) between periods (Table 3). Bark cover on ponderosa pine decreased 20%, whereas that on sugar pine decreased 29% (both $P \leq 0.001$). Thus, bark cover for total fir decreased only 4%, whereas total pine decreased 24%.

About 95% of all stumps showed some signs of arthropod activity (e.g., bore holes, sawdust, pitch tubes), and about 60% showed signs of external sapwood fungal development.

DISCUSSION

These results showed that within the first 5-6 years of creation high-cut stumps are used for foraging; use for nesting was minimal. Findings for deterioration of, and bird feeding activity on, taller snags correspond closely to my results for stumps (e.g., Cline et al. 1980, Mannan et al. 1980, Swallow et al. 1988). Feeding activity should slowly decline as stumps continue to decay and likely become minimal after 10-years post-creation, because most bark will have dropped off and the stump will have become very soft by that time. Nest excavation might continue or even increase 10-15 years post-creation as the interior of stumps soften (Cline et al. 1980).

No obvious relationship was found between decline in hardness, bark cover, and woodpecker feeding activity. Pine decayed the most, but it showed little difference in feeding activity by birds relative to fir. Other studies in the Sierra Nevada have shown that pine decays more rapidly than fir (e.g., Raphael and White 1984, Raphael and Morrison 1987). All species except incense-cedar were used substantially for

Table 3. Decline in bark cover on high-cut stumps between time of creation (1984-85) and 1990, western Sierra Nevada, California.

Species ^a	1984-85		1990		<i>P</i> ^b	Percent decline
	\bar{x}	SD	\bar{x}	SD		
Douglas-fir	98	8.3	93	10.3	0.016	5
White fir	96	7.3	94	10.4	0.424	2
Sugar pine	95	6.8	67	32.6	0.001	29
Ponderosa pine	97	6.0	78	20.2	<0.001	20
Incense-cedar	100	0.6	99	3.0	0.230	1
Total fir	97	5.8	93	10.3	0.018	4
Total pine	96	6.3	73	26.1	<0.001	24
Total conifer	97	5.8	84	21.7	<0.001	13

^aSpecies, species categories, and sample sizes defined in Table 1.

^b*t*-test.

foraging. The relative insect resistance and decay patterns of incense-cedar are apparently responsible for its low use by birds. Living incense-cedar is, however, an important foraging substrate for birds during winter (Morrison et al. 1989).

Previous work showed a nesting preference by birds for snags >5 m tall (e.g., see Morrison et al. [1983] for review). Also, although used for foraging, stumps obviously provide much less bark surface area than taller snags. I concur with earlier recommendations (Morrison et al. 1983) that stumps only be used in situations where snags present obvious safety or logistical problems, and they not be considered adequate nest substrates. Both firs and pines can be used for stumping, with a slight preference given to using firs because of their slower decay rate. Incense-cedar should be avoided for use as high-cut stumps, if possible.

ACKNOWLEDGMENTS

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BOOK REVIEWS

NATURAL HISTORY OF THE WHITE-INYO RANGE, EASTERN CALIFORNIA

Edited by Clarence A. Hall, Jr. 1991. University of California Press, Berkeley. xvii + 536 p. \$75.00 cloth; \$24.95 paper.

The White-Inyo Range is located east of the Sierra Nevada and the Owens Valley, in Mono and Inyo counties, California. As such, it is in the southwesternmost part of the Great Basin. It is one of the highest desert ranges in North America and contains the largest expanse of Alpine Steppe in the western United States. Because of its location on the edge of the Great Basin, the White-Inyo Range is of great interest from a biogeographic standpoint.

This natural history volume is modeled after the now classic handbook by Tracy Storer and Robert Usinger, *Sierra Nevada Natural History* (University of California Press 1963); it is Volume 55 in the California Natural History Series. The book is an ideal companion volume for Storer and Usinger's work, extending valuable reference information eastward to Fishlake Valley, Nevada, along the eastern front of the White-Inyo Range. It will be of great interest to those desiring a succinct introduction to the many aspects of the natural history of the region.

Natural History of the White-Inyo Range, edited by C. A. Hall, Jr., Director of the White Mountain Research Station in Bishop, California, was nearly 11 years in the making. Unlike *Sierra Nevada Natural History*, this volume is the product of a collaborative effort by numerous authors, each a specialist in a chosen field. As such, it includes very detailed information in the 13 chapters that comprise the book. Unfortunately however, the diversity of the White-Inyo Range precluded a discussion of all of the plant and vertebrate species that are known to occur there. For example, only one-third (356 of the 1,094) of the taxa of grasses and flowering plants known to occur in the region are considered. Among animals, 113 taxa of insects are described, as are 4 fish, 8 amphibian, 37 reptile, 85 bird, and 45 mammal taxa. Additional chapters include Weather and Climate, Geomorphology, Geologic History, Plant Zones, and Native Land Use.

This volume includes, in one handy reference, a multitude of information that will be of value to beginning students of the region, and good summaries that will be of value to experienced researchers. As a scientist working primarily with populations of terrestrial vertebrate species, I found the chapters on fish, herptiles, birds, and mammals to be somewhat mundane; however, the information contained in the chapters on weather, geomorphology, geologic history, and anthropology were most informative. That bias, no doubt, reflects my familiarity with the local vertebrate fauna, as well as my lack of familiarity with climatology, geology, and cultural anthropology, in general. Road logs included in the chapter on geologic history are of special interest, as is a multi-colored geological map; these will provide me a special opportunity to become more familiar with areas of scientific endeavor well beyond my realm of expertise. Chapters on arthropods, plant communities, grasses and flowering plants, and trees of the region round out the volume; these will all be of interest to students of the White-Inyo Range who are not specialists in those disciplines.

The text is readable, and has been well-edited. I noted only one misspelling, (*Mammology*, p. v), and expect to find very few more as I use this volume over the years. The color plates ($n = 325$) are of good quality, and will be very useful to those seeking to identify plants, amphibians, reptiles, and some birds and insects that they may encounter; included, and of special interest to me, is a series of eight color photographs depicting cloud types. Line

drawings accompany the chapters on arthropods, fishes, birds and mammals, and will add to the utility of those chapters. All chapters, with the exception of Mammals, include a list of additional references to help users of this *Natural History* obtain additional information on the subject at hand; it is unfortunate that the authors of Chapter 12 chose to not include a list of appropriate references.

This book is the result of a combined effort by 19 individuals who have spent untold years working in the White-Inyo Range. Many, if not all, of the authors have worked extensively through the White Mountain Research Station, pursuing scholarly research in their fields of expertise. The interest that the White-Inyo Range holds for the individual authors is obvious, and it is no surprise that four of them have chosen to make their permanent homes in the Owens Valley, in the shadow of the fascinating mountain range that is the subject of this book.

I recommend this book for those seeking to enhance their general knowledge of the natural history of eastern California and, especially, to those who will be exploring the White-Inyo Range. The book is of a convenient size, and will slip easily into a daypack. I am unconvinced however, that the binding of my copy will withstand much in the way of heavy use; the primary improvement that could be made in the book is the quality of binding on the paperback version. For those who intend to use this book as a constant field reference, purchase of the hardbound version should be considered. The price is such, however, that one could purchase three paperback copies for the cost of a single hardbound copy.

—Vernon C. Bleich

California Department of Fish and Game

MIDNIGHT WILDERNESS: JOURNEYS IN ALASKA'S ARCTIC NATIONAL WILDLIFE REFUGE

by Debbie S. Miller. 1990. Sierra Club Books, San Francisco, CA. xvii + 238 p. \$19.95.

The Arctic National Wildlife Refuge (ANWR) represents one of the largest and most unspoiled tracts of wildlife habitat in North America. ANWR is a huge area, stretching nearly 400 km eastward, from the Sagavanirktok River to the Canadian border, and approximately the same distance northward, from the Porcupine River to the Beaufort Sea; ANWR occupies much of northeastern Alaska. It is home to a multitude of wildlife species, including numerous kinds of shorebirds and waterfowl, muskox, grizzly bears, Dall sheep, wolverines, wolves, and raptors. Perhaps, it is best known for the Porcupine Caribou Herd, that ranges across the international border and contains 180,000 animals. ANWR is becoming increasingly well known because of the controversy surrounding proposed oil development within the "1002 Area", on the Arctic Coastal Plain.

Debbie Miller has written a book that must be read by all concerned with the preservation of wild places. Her intimate knowledge of ANWR has been gained over many years, by experiencing the Refuge through numerous trips with her family and friends. An experienced Arctic traveler, Debbie conveys in this book the importance of maintaining ANWR as pristine wildlife habitat for the wild creatures dependent upon it, as well as for its significance as one of the largest, unspoiled regions remaining in North America. Debbie lived for many years in Arctic Village, on the southwestern boundary of ANWR and relates, first hand, the importance of ANWR both to wildlife and to native peoples; she is equally able to relate its importance to those not so fortunate to have experienced the pristine Arctic themselves.

Midnight Wilderness is based on many writings from Debbie's journals, describing the grandeur and solitude of ANWR. She discusses, first hand, ongoing conservation activities within the refuge, as a result of her friendship with many of the personnel involved in research and management there; indeed, her husband, Dennis, is a contract pilot researching the Porcupine Caribou Herd. Her writings reflect the camaraderie she and Dennis feel with those fortunate enough to be working in such a pristine part of the world, and an intimate knowledge of the importance of ANWR to wild things.

Midnight Wilderness includes a chapter on the history of the establishment of the Refuge, aptly entitled, "The Dream and the Fight." Admirably, Debbie has thoroughly researched the history of ANWR, and she incorporates into her writing the results of interviews with many of the individuals who dreamed the dream and fought the fight. This chapter, clearly, is of historical importance.

Midnight Wilderness concludes with a description of a week spent at Prudhoe Bay, northern terminus of the Alaska Pipeline, followed by a chapter reflecting on two weeks that Debbie and her year-old daughter, Robin, spent camped along the Aichilik River in an, as yet, unspoiled Arctic wilderness. The stark contrasts that are obvious between these two areas are made even more apparent by the juxtaposition of these chapters. Entitled "Coming Home," the final chapter emphasizes the importance of preserving ANWR, in language that might sway even the strongest advocates of oil development.

I was fortunate enough to be a dinner guest in Debbie Miller's home during a recent trip to Fairbanks. The enthusiasm that she and Dennis share for the wild and pristine Arctic was evident throughout the evening. The hopes and fears expressed in *Midnight Wilderness* are messages that Debbie conveys as well in person; I hope that others will listen to the wisdom expressed in *Midnight Wilderness*. As Debbie inscribed in my copy of *Midnight Wilderness*, "I hope you enjoy this book, and have the opportunity to visit the Arctic Refuge." Based upon my own brief experiences on the North Slope of the Brooks Range, I would extend that hope to our children, grandchildren, and all future generations. To deny them the opportunity to visit one of the last, unspoiled parts of planet Earth, in the interest of short-term financial gain, is an unacceptable option.

As Margaret Murie questioned in the Preface to *Midnight Wilderness*, "Will our society be wise enough to keep some of 'The Great Country' empty of technology and full of life?" I hope so; and, if that is to be, *Midnight Wilderness* surely will play a role in the realization of that dream. Buy it, read it, appreciate it, and let your views be known.

—Vernon C. Bleich

California Department of Fish and Game

IN MEMORIAM

Five people, among them two Department of Fish and Game employees, were killed in a helicopter crash in the Carquinez Strait on Saturday, January 11, 1992. Greg Cook and Sonia Hamilton worked for the newly established Oil Spill Prevention and Response (OSPR) office and were investigating a potential oil spill over the Carquinez Strait when the helicopter they were riding in struck a power line and crashed into the strait.

Lieutenant Carl S. Johnson, U.S. Coast Guard; Robert Jean, a consultant for Clean Bay Oil Spill Cooperative; and pilot Charles P. Walters were killed in the tragic accident.

Greg Cook- August 7, 1947-January 11, 1992. Greg joined the Department in 1983, becoming a warden and one of the original instructors of the Warden's Academy. He had been recently assigned as an environmental specialist in OSPR. Greg is survived by his wife and two children.

Sonia Hamilton- April 20, 1956-January 11, 1992. Sonia began working for the Department in 1985 and spent five years with the Bay-Delta Project before joining OSPR as an environmental specialist. Sonia is survived by her husband.

A trust fund has been established for Brian and Matthew Cook, the children of Greg and Ann Cook. Contributions can be sent to the: Brian and Matthew Cook College Trust Fund, PO Box 5928, Napa, CA 94581.

A scholarship fund to aid students in marine sciences has been established in Sonia Hamilton's name. Contributions can be sent to the: Sonia Linnik Hamilton Marine Sciences Scholarship, CSU, Stanislaus, 801 West Monte Vista Ave., Turlock, CA 95380.

Both will be missed by their friends and colleagues. -*Eric R. Loft*, Editor, adapted from OSPR Report.

INSTRUCTIONS FOR CONTRIBUTORS

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